EXCAVATION

1. Why Pay Attention to Sitework?
2. How Erosion and Sedimentation Control Starts the Project?
3. What You Should Know about Clearing and Grubbing?
4. What to Consider for Site and Building Demolition?
5. What You should Know about Earthwork Excavation and Compaction?
6. What are the Basic Pieces of Site Equipment on a Project?
7. What You should Know about Rock Excavation?
8. How Water Affects Sitework?
9. What Public Domain Documents are Available for Further Study?
10. Tricks of the Trade & Rules of Thumb for Excavation:

Why Pay Attention to Sitework?

On too many projects, the Construction Supervisor allows the Excavation Foreman to make most of the major decisions for the site work staging and planning. It seems to make sense to allow the Excavation Foreman to make these decisions, since his crews are doing the work. This assumption causes many problems on projects that could have been easily avoided.

The Excavation Foreman generally focuses on the most efficient method to get his required work items done. Generally the excavator's goals can be visualized if the dirt were being moved with a stick; pushed from the high areas to the nearest low areas with a minimum of carrying. Sometimes the most efficient method for the Excavation Foreman is also the best plan for the entire project. Many times, though, project complexities exist that are beyond the excavator's scope of work. In these cases, the Construction Supervisor should make sure the planning considers what is best for the entire project, not just for the Excavator.

A simple method that works well involves a color marked site plan that the Construction Supervisor develops just for job staging and planning. The Construction Supervisor needs to consider fill pile locations, topsoil pile locations, haul roads, building layout points, building material storage locations, parking areas, office trailer locations, etc for the various phases of the project.

Perhaps several color marked up site plans will be needed to show what happens at the various project stages. Each project is different and requires a slightly different approach. But the one consistent rule: lack of site work planning for the various project stages by the Construction Supervisor will definitely not achieve an optimized project.

A good Construction Supervisor considers the various requirements for foundation, site utilities, access and storage, dewatering, etc. and helps plan a detailed sequence of excavation. This planning process should include as many of the effected parties as possible to insure success. Be forewarned, it will be difficult to get people to take the time to plan. Planning, by definition, involves taking uncertain dates and requirements and looking into the future to make decisions. Many people are uncomfortable with this process and will try to avoid it. Good planning requires thought and negotiating and is hard mental work.

Top of Page

How Erosion and Sedimentation Control Start the Project?

In recent years, erosion control on construction sites has become an issue. Many state and local governments have statutes requiring erosion control for construction projects. Often inspectors have the authority to shut-down an entire project for erosion

Topics
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control concerns. The effects of erosion can be summarized as three-fold:

1. Damage to stream channels: stream channels downstream become filled with sediment and flooding can occur.
2. Damage to water: sediment lowers water quality for municipal and industrial use.
3. Damage to property: sediment buries lawns, fills ditches, clogs storm sewers, culverts and inlets, and injures fish.

Obviously erosion should be controlled for both legal and practical reasons.

Erosion is defined as the detachment and transportation of soil particles. Rain falling on bare soil detaches particles and as the rainwater runs off soil erosion occurs in proportion to the water volume and velocity. The eroded soil particles are deposited when the water slows and the soil particles settle.

Erosion can be controlled through both mechanical and vegetable measures. One of the most effective mechanical measures involves grading, or disturbing, only those areas immediately needed for construction. Limiting the area of exposed, bare soil greatly reduces erosion. This method of erosion control can often appear to be at odds with the excavator's goal of completing the project quickly and efficiently. Adequate planning of the grading work, which always involves considering several different options, may reveal a solution that meets both the goals of erosion control and efficient grading.

Subsurface trench drains, discussed in the groundwater section of this chapter, are another means of controlling erosion. Trench drains can divert water at the top of a slope or collect and carry fast moving water away at the bottom of a slope. Swales and berms can also be used to divert and channel run-off. Before leaving the site, this run-off must be slowed to allow the sediment to settle. Sediment basins are used to detain runoff and trap sediment. A well constructed sediment basin should have capacity to hold adequate runoff, prevent runoff short-circuits past the basin, and be accessible to clean-out sediment.

Vegetative measures to reduce erosion control can be very efficient and economical. The slope of the site and fertility of the soil help determine the effectiveness of vegetative measures. Straw, or other fibrous, mulch can be applied directly to soil slopes during an unfavorable time of year for seeding. Straw mulches are usually applied at 1-$^1/_2$ tons per acre. Straw mulching must be anchored asphalt tack spray, straight blade, disking, or netting.

There are times in the year when permanent seeding is prohibited, but temporary seeding may be successful. Annual rye grass, small grain, sudangrass and millet are often used for temporary seeding and, with a little luck from the elements, do an excellent job of preventing erosion. The ideal situation, generally, is to install permanent seeding as soon as grading is complete in an area. If required, sod can be placed in almost any weather conditions and can reduce erosion almost immediately.

What You should Know about Clearing and Grubbing?

The process of removing and disposing of brush and trees is described as clearing. Grubbing is defined as removal and disposal of stumps and roots. Clearing and grubbing is generally performed concurrently in order to ready the site for topsoil stripping and bulk excavation. Since clearing and grubbing happens as the first work item on the project, it is usually critical to the project schedule. Therefore, the Construction Supervisor needs to understand the process of clearing and grubbing in order to control the project.

Clearing and grubbing is often thought of as a simple process, but there are many options and complexities involved. There are several methods of disposing of brush, trees and stumps, depending on project conditions and local ordinances. Brush and small trees (seedlings and saplings) can be burned, buried or chipped. In order to discuss tree usage it is helpful to use the U.S. Forest Service size classification.

Name	Diameter in inches at breast height or (DBH)
Seedlings	0” to 3”
Saplings	3”to 4”
Poles	4” to 12”
Standards	12” to 24”
Veterans	Over 24”

Poles may be burned, buried, salvaged for future use or sold. While standard and veteran size trees are often salable to saw mills.

Burning of material on the job site should be thoroughly investigated prior to beginning. State environmental laws and local ordinances should be checked. If burning is allowed, it can be an efficient and low cost way of disposing of brush, trees and stumps. Usually a good, hot fire can be started with brush and small trees. Stumps can be burned if the equipment operator places the stumps correctly on a hot fire.

Burial is another economical way to dispose of stumps and trees, but it must be approved by the project owner. Be aware that large stump holes, which are often filled in with loose, un-compacted soil, become settlement problems. Don't allow the Sitework Contractor to just bury at the most convenient spot, causing a later problem for you or the Owner.

The actual procedure of burying stumps and logs is straight-forward although considerable care should be given to the location of buried items. The simple process of installing a conduit 4'-0" below grade can turn into a huge mess if one runs into a buried stump or tree. As this is often a problem that one subcontractor unwittingly creates for another, the Construction Supervisor should be aware about the burying of material on the project site. Chipping, hauling away and sales to a lumber mill are also methods of disposal. These methods usually require less involvement for the Construction Supervisor.

While considering the clearing and grubbing, keep the following items in mind: amount and type of trees and brush, dangers from dead limbs, soil conditions when wet, possibility of working over frozen soil, and general access to the site.

Top of Page

What to Consider for Site and Building Demolition?

Site demolition includes removal of catch basins, manholes, underground pipe, asphalt paving, concrete paving, etc. The method of disposal of site demolition materials can have a large impact on a project. If the material is hauled to a dump site, the Construction Supervisor should know the dump site location and be assured that the dumping meets all state and local ordinances.

I've had a major project can be stopped because a neighbor to the dump site complained and found that we didn't have the proper permits. It is simply not enough, in today's environment, to merely get permission of the landowner to place fill on their property.

If site demolition materials are also disposed on site (either buried or broken and used for rip rap) the Design Professional or Owner should give requirements for this type of use (i.e. maximum size of fill lift, equipment used to compact, maximum size piece allowable, requirements for wood, rebar, etc. found in the materials, etc.).

Another important question concerning site demolition work is limits of work. The Construction Supervisor should be clear on what the limits are, who is responsible for establishing those limits in the field and who will be responsible for damages if those limits are exceeded. Limits should also be established for specific items of demolition. For example if a catch basin and storm pipe crossing an existing street must be removed, the Construction Supervisor should help determine if the pavement will be chisel cut or saw cut and the width of the cut. The Construction Supervisor can be very effective by keeping the information flowing if one subcontractor performs demolition and another restoration.

Building demolition can vary from removing some doors or walls in an existing structure to razing an entire building. The work is extremely varied and runs from the simple to the complex. Understand the demolition requirements before you start!

Building demolition work is usually not well understood at the onset of a project. Describing the work to be performed is necessarily tricky because it normally involves areas of unknowns. For example, it's difficult to know the material inside a wall that support a lintel. Regardless of the unknowns, the Construction Supervisor must work to clarify the intent of the demolition work. Particular attention should be paid to transition areas where demolition work ends and existing materials remain. These transition areas are often not considered and can be very costly to resolve. Lastly, the Construction Supervisor must understand the contracted responsibilities for demolition and try to reveal and resolve changes as soon as possible.

One item that requires special mention regarding building demolition is hazardous materials. Due to the technical, health and legal problems involved, asbestos, lead paint, or any other hazardous material should be removed by qualified, licensed personnel only. The liabilities are so huge with these materials that the Construction Supervisor should defer decisions in this area to his employer.

Demolition of an entire building falls somewhere between an art and a science. Usually the responsibility will be let to one subcontractor. The Construction Supervisor should understand the method to be used, precautions used to project neighboring buildings, techniques, if any, of monitoring of neighboring buildings for damage, dump site location and requirements, and proposed finish condition of site for next contractor to begin work.

Top of Page

What You should Know about Earthwork Excavation and Compaction?

Earth excavation and grading can be a fascinating part of a construction project. The powerful heavy equipment, used to best advantage by a skilled operator, is a joy to behold. The scope of the excavation job varies from digging footings for a small building to moving millions of cubic yards of earth. The one thing all excavation jobs have in common, though, is that careful planning is the key to success.

There are several terms which should be defined. Excavation is often used as a broad term which includes cut (or excavation) and fill (or embankment). Cut is defined as removing material to lower the elevation of an area. Fill is defined as placing material to raise the elevation of an area. Compaction must take place during a fill operation to increase the density of the soil material being placed. Another common breakdown in excavation work is bulk excavation and trench excavation.

Swell and shrinkage are two important, and often misunderstood, terms. Consider the simple example of digging a 1.0 cubic yard hole with a shovel and throwing the dirt into wheelbarrows. In the ground the 1.0 cubic yard of soil is in its virgin (or natural) state. Upon being shoveled into the wheelbarrows the soil is in a loose (or lower density) state and probably has a volume of 1.2 to 1.4 cubic yards. This process of soil increasing in volume from its virgin state to a loose state is called swell.

Shrinkage, on the other hand, occurs when that same soil is placed back in the one cubic yard hole and is properly compacted. Depending on the soil type, the final volume could be 0.9 cubic yards or 1.1 cubic yards. The above explains why when one digs and refills a hole, sometimes there is not enough soil to fill the hole and sometimes there is soil left over.

An excellent table showing weights, swell factors, and shrinkage factors for various materials is included below. The table of characteristics is a growing body of knowledge with many contributors over the past 100 years. All the values given are necessarily approximate. The rock materials are labeled in the following way: I, igneous; S, sedimentary; or M, metamorphic. The cubic yard in cut column assumes natural moisture and has + 10 percent variation. The cubic yard loose column has a +33 percent variation. For example, damp clay with a given swell of 40 percent should be assumed to have a swell range of 30 percent to 53.2 percent. The cubic yard in fill column also has a 33 percent variation and assumes mechanical compaction at appropriate moisture levels.

In earth excavation and site grading some of the most common problems encountered are improper compaction, incorrect final elevations, and working beyond the specified area to be disturbed. There are no magic, simple answers or procedures to make the above problems not happen.

Improper soil compaction is a common, and often difficult problem. Soil Engineering and Geology, a previous section, discusses the technical aspects of soil compaction. The practical, in the field problems include:

1. Soil too wet: must be aerated or mixed with dryer materials.
2. Soil to dry: must add water
3. Soil lifts for compaction too deep: lessen lift depth
4. Different types of soil: check if the proctor test (the test which measures the density of the soil sample for other tests to be measured against) matches the type of soil encountered
5. The soils inspector holds-up the compaction operations to takes tests: try to create a team environment and plan test taking for everyone's advantage.

The problems of incorrect final elevations and working beyond the specified contract limits are more straight-forward. The excavation contractor certainly should be responsible for their own work, the only real problem involves determining the mistake. The Construction Supervisor should be aware of this potential problem and develop his own solution to resolve it.

In general, the best solutions follow:

1. The Construction Supervisor should be aware of the specific requirements as much as possible (i.e. understand the whole job) and spot check on occasions.
2. Whenever practical the subcontractors following the site grading should check and accept the previous work prior to beginning.

Even though the excavation contractor is ultimately responsible for their work, project schedule or quality can be ruined if errors are found too late. The above are some problems encountered in the field with possible solutions. In many cases the solutions seem simple to apply but are quite difficult and costly. Regardless of the complexity, the site work is almost always critical to the timely completion of the project and must be a priority for the Construction Supervisor.

Top of Page

What are the Basic Pieces of Site Equipment on a Project?

The advances in our ability to move earth and rock since the early 1900's is truly impressive. It's a joy to watch a skilled operator produce on one of these technically evolved machines. Bud Caldwell, a great Construction Superintendent from the 1950s to the 1980s, remembered construction before the heavy equipment.

"As a boy, I helped with earthmoving on construction projects. There was a steel scoop with two handles that could be pulled like a plow. I'd hook-up the team of mules to this scoop and drive through the excavation area, scraping a couple of inches of soil at each pass. It was a slow process. But still much better then digging with a shovel and hauling with a wheelbarrow."

The mules are now replaced with diesel engines and the scoop has been transformed to perform many specialized tasks. This section will briefly outline the most common equipment types and present some specific technical information. Though it is the Site Contractor's job to thoroughly understand the function, cost and maintenance of the equipment; the Construction Supervisor should understand basic heavy equipment characteristics and uses to help plan the job. This review of equipment in not comprehensive, but rather an introduction to commonly used heavy equipment on building projects.

The **Bulldozer** is a simple, versatile machine that has a tremendous number of uses. Generally a self-propelled track machine, the bulldozer pushes or pulls only. Conversely, a front end loader uses a front bucket to lift soil to load a truck. The bulldozer uses include:

1. Clearing and grubbing
2. Grading earth for short haul distances
3. Pushing scraper pans
4. Ripping rock
5. Spreading borrow fill
6. General site maintenance

The sizes of bulldozers vary greatly from small machines that use 6-way tilt blades for fine grading to huge machines that need special permits to be hauled over bridges. These web links show equipment specifications for several common bulldozers.

http://www.cat.com/cda/layout?m=37840&x=7

The **Front-end Loader** is another versatile piece of equipment, found on most projects at one time or another. Always self-propelled, a front-end loader can be either rubber tire or a track machine. A front-end loader has a front bucket that tilts vertically to load and unload and lifts vertically. The front-end loader uses include:

1. Clearing and grubbing
2. Excavate and carry soil
3. Excavate and load soil into a truck
4. Grading and spreading borrow (although less ideal then a bulldozer)
5. On-site material transport (rebar, pumps, etc.)

Particular attention should be paid when a front-end loader excavates and loads soil onto a truck. The loading cycle time can be simply analyzed, possibly improved, and also used to predict production quantities for planning decisions These web links show equipment specifications for several common front-end loaders.

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Scrapers or Pans excavate soil in one location, haul and dump the soil in another spot. It is difficult to match the efficiency of scrapers for cut/fill soil operation if the haul distance is less then a mile. Scrapers are generally pulled by a rubber tire wheel tractor and are sometimes pushed through the cut area by a bulldozer. These web links show equipment specifications for several common scrapers.

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There are many times that scrapers are not used for site grading and a dump truck is employed: the haul may be to long, the haul may cross roads where scrapers are not permitted, hard rock may be encountered, equipment availability, etc. Dump trucks are in common use and probably require little discussion. The Construction Supervisor should be aware of a difference in bed types. Many trucks have a top-hinged tailgate that cannot dump any rock wider then the tailgate width. "Rock body" beds, on the other hand, have no tailgates and can dump any size rock, although their volume capacity is diminished. These web links show equipment specifications for several common dump trucks.

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Compaction Equipment increases the density of the soil and in some cases provides a smooth, rolled surface. Compactors achieve these results by either static weights or vibration. Care must be taken when using a vibrating compactor concerning nearby structures and pumping excess water up through the soil. The vibrations can literally causes nearby buildings to fall down. The compactor surface that touches the soil can be classified as either steel drum, pneumatic rubber-tired, or sheepsfoot. Compactors can be either self-propelled or towed. These web links show equipment specifications for several common compactors.

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Hydraulic Excavators are extremely useful machines for both bulk excavation and trench excavation. Usually self-propelled on tracks, excavators operate hydraulically. The cable driven power shovels are the forerunner of the modern day excavator. These web links show equipment specifications for several common hydraulic excavators.

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Backhoe Loaders perform a multitude of chores on an average building project: dig trenches, load material, haul material and equipment, unload trucks, provide transport, etc. Backhoe loaders are self-propelled and rubber-tire machines. These web links show equipment specifications for several common backhoe loaders.

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So take some time and learn the basic equipment that Sitework Contractors use. Remember, the person who calls every piece of equipment on the jobsite a "Bulldozer" labels himself as a dope.

Top of Page

What You should Know about Rock Excavation?

Rock excavation solutions vary greatly. The best method to remove rock in an excavation must be reassessed continually for changing conditions. However rock excavation is a fact of construction life and must be anticipated by the Construction Supervisor.

Prior to a project beginning, an Owner has probably already considered the possibility of rock in the excavation area and the associated costs. The Owner makes a decision during the design stage about the amount of geotechnical information required. The Owner has many exploratory options available. From a simple test pit to percussion drilling to core drilling the owner has increasingly more expensive options that yield increasingly better data about the site underground.

For example, the Owner on a 100,000 SF building project may authorize twenty boring locations with split spoon soil samples taken until rock is reached and then core samples of rock. This information can be carefully studied by the Construction Supervisor and Sitework Contractor and used to help make the project schedule. Knowing the type and quality of rock (from the core samples) and location of rock (from the soils boring) is a real advantage in jobsite planning.

Conversely, the Owner of a 100,000 SF building may decide to proceed with no geotechnical testing whatsoever. The decision about geotechnical testing is usually made by an Owner with no input from the Construction Supervisor.

All too often, though, some geotechnical testing information is available to the Construction Supervisor and is not properly utilized. The section on Soils and Geology helps you understand the terms in the geotechnical report.

A knowledge of the approximate location of the rock helps the Construction Supervisor to plan the sequence of steps following rock excavation. If rock is in one corner of a large building project, for example, the earth excavation could begin at the opposite end of the building in order to start foundation work soonest. This simple example indicates the usefulness of rock core borings (which show the type and quality of rock encountered). Beginning the foundation work early would be a good idea if the rock could be removed by ripping. However, if the rock is extremely hard and requires substantial blasting, it may be prudent to hold foundation work until the blasting is completed. The Construction Supervisor should coordinate these types of decisions and use all the technical date available.

Think about payment terms for rock on each project. Unclassified excavation stipulates that all rock or other unexpected materials (excluding hazardous materials) encountered in the sitework will be the responsibility of the Contractor at no change in contract cost. An unclassified excavation is simpler from a book-keeping standpoint and places the responsibility for geotechnical conditions onto the Sitework Contractor.

Classified excavation, on the other hand, defines rock and makes provisions for measurement and payment of any rock encountered at an agreed upon unit price. This method places the rock payment responsibility onto the Owner. The Construction Supervisor must be aware if the excavation is classified or unclassified. If classified, the Construction Supervisor must help set-up clearly understood procedures for definition and measurement of rock quantities.

Rock is removed by ripping, blasting, or breaking, depending on the rock type, quality and quantity. Ripping is a mechanical splitting of rock by inserting a steel point into a rock crevice and applying force. The force is usually supplied by a bulldozer. Blasting involves explosives placed in drill holes and detonated. Breaking of rock by a hydraulic hammer bit mounted on an excavator is used when the rock quantity is small or blasting is not feasible.

If blasting is required for rock excavation, the Construction Supervisor should be assured that the work is performed by a licensed blaster and that the proper permits have been obtained. The effect on existing structures and nearby work should also be discussed with the blaster.

Top of Page

How Water Affects Sitework?

It's amazing what a heavy rain can do to a construction project. Prior to the rain, the site may be dry, heavy equipment efficiently moving earth, the other trades smoothly performing their work. Within hours the project can be a sloppy, mud-hole with worker efficiency cut to about 10%. In many cases, the change comes mostly from poor planning. In most areas of the world, the Construction Supervisor must remember a simple fact: IT WILL RAIN.

Good planning can minimize the damage and disruption of a heavy rain to a jobsite. Often the excavation and grading is left to the Sitework Contractor (and their Foremen is responsible to supervise and direct the heavy equipment and operators). But remember, the Construction Supervisor is responsible to complete the entire project in an efficient, timely manner. Therefore the Construction Supervisor must be continuously aware of what rain will do to the project site. It is not uncommon for the Sitework Foreman to work their heavy equipment for maximum efficiency and hope it doesn't rain.

One of the best ways to prepare for rain is to slope all grades to drain and to smooth rolled the surface prior to a rain. This work can cut down on short-term productivity, but can really help a jobsite more quickly recover from a storm. The Construction Supervisor must be far-sighted enough to insure that heavy rain does not stop work on the project longer than necessary. Daily discussions with Sitework Foremen may be required to achieve this goal.

Any time excavation is required below the existing water table on a project, the process of dewatering must be considered. Generally dewatering is required because of a high level of ground water (underground streams and springs) in areas with cohesionless (sandy or gravelly) soil or water yielding rock. In a truly cohesive soil, the water travels so slowly through the clay or silt that dewatering is not usually necessary for the relatively short time of excavation.

Dewatering may be required for a single footing excavation or for an entire project site. The most common dewatering methods are trench drains, deep wells and well points. A variety of pumps and piping types are used with these systems. Ground water seepage can also be decreased by cutoff methods such as sheet piling.

The costs for dewatering can be staggering, including equipment rental, labor and electricity (or fuel). High dewatering costs have paled the profit margins on far too many projects. The many variables listed below make the job of estimating dewatering costs very difficult, and very inexact.

1. Specific soil and rock characteristics and locations.
2. Groundwater location, extent, direction and rate of movement (including seasonal variations).
3. Most efficient dewatering method: trench drains, deep wells, wellpoints.
4. Effectiveness of cutoff structures.
5. Time period dewatering is required.
6. Costs associated with dewatering system failure (mucking out and cleaning).
7. Costs associated with over dewatering (damage to adjacent structures).

In dewatering, the simplest solution is often the best. On many sites dewatering can be accomplished without pumps, using gravity, by the use of trench drains or siphons. This option should always be considered when analyzing the prospect of dewatering. Obviously the option is only viable if gravity can run the water to lower ground. Trench drains can be cut with a backhoe and filled with a coarse, granular material (#4 stone for example), but care must be exercised in choosing the water outlet type and location.

Siphons present an economical, and often overlooked, method of dewatering. A siphon, by definition, uses atmospheric pressure to carry water from one elevation, up over an obstacle, to a lower elevation. The pipes in a siphon system must be airtight and some ingenuity is often required to completely fill the siphon pipe. The siphon pipe must be full for the siphon to begin. The time required for siphon dewatering is usually longer then for pumps since the force moving the water is atmospheric pressure, not electricity or gasoline.

A deep well consists of a pump, hose and a vertical well casing. The pump intake is at the bottom of the well casing (usually some crushed stone is placed down there as a filter medium). The water is pumped up the hose, out of the well casing, and to a suitable discharge location. The effectiveness of a deep well depends mainly of the permeability of the soil. In a coarse sand, for example, a large area can be pumped to near the pump intake elevation. A less permeable soil, on the other hand, reduces the effectiveness of a deep well. Since the pump is generally at the bottom of the deep well, there are no height limitations due to vacuum lift, and deep wells can lower the groundwater over 50 feet.

Wellpoints are the most complex dewatering system discussed here. The wellpoint system is composed of vertical wellpoints (commonly 1-½ inches diameter) connected to a header pipe at grade and a vacuum/discharge pump at grade. The wellpoints operate on the principle of vacuum and have a maximum depth of about 15 feet. If deeper dewatering is required, successive sets of wellpoints can be installed at lower elevations.

The vertical wellpoint is actually jetted into the ground with water. On the bottom of the wellpoint there is a 2 foot long screen and valve, water jets out of this valve and creates a hole into which the wellpoint pipe can be lowered. This hole is often made a larger diameter (for example 10 inches) to allow for a coarse sand backfill to help filter the water. The wellpoint spacing depends on the permeability of the soil, but 2 feet to 6 feet centers are common. On average a single pump can handle up to 50 wellpoints.

The jetting portion of wellpoint work generally results in quite a bit of mud and muck at grade. The Construction Supervisor should assure that provisions are made for this material to be removed. While the wellpoint system usually does an excellent job of dewatering, the pipes also cause significant congestion at grade. Since the Construction Supervisor manages the project site, he should strategically place the wellpoints and headers to minimize conflicts.

Pumps are the most important, and the most troublesome, piece of equipment in most dewatering schemes. Most dewatering pumps are described by the following categories:

1. Centrifugal pumps
   a. suction pumps
   b. submersible pumps
2. Diaphragm pumps (or trash pumps)

Centrifugal pumps come in a great variety of sizes, from a 1-½ inch to over 12 inch nominal discharge diameter. The most common sizes are 2 inch and 3 inch nominal discharge diameter. Centrifugal pumps can be driven by gasoline or diesel engines or be electrically powered. If gas or diesel, provisions must be made to keep fuel in the tank; these solutions range from assigning the responsibility to someone to special valves that feed fuel from 55 gallon drums. Special care must be used with liquid fuel on the jobsite.

Electric pumps tend to be easier to use in many ways, but safety is an important aspect here also. It is extremely disconcerting to be standing ankle deep in water, working on a pump, and realize that the guy who wired it didn't know a volt from an amp. Even though it seems trivial, get an electrician to wire dewatering pumps. Using the proper breaker, wire size and ground fault protection is essential.

Centrifugal suction pumps have a rigid suction line (to prevent collapse) and lift water up the level of the pump. Fifteen to twenty feet is the maximum height that water can be lifted by suction. Some centrifugal suction pumps are self priming, but many must be primed prior to each use, which can be labor intensive and annoying.

The centrifugal submersible pump operates in the bottom of the hole. There is no suction line, the pump must be flooded. With proper float controls these electric pumps can be quite trouble free.

Diaphragm pumps are the workhorses of construction dewatering; pumping mud, sand, small rocks, and trash (pumped material can be up to 70% of the size of the pump intake). The diaphragm pump uses a rigid suction line and is generally self-priming. The responsibility for installing and maintaining construction dewatering pumps must be clearly assigned. Sometimes weeks of work can be ruined if the pumps malfunction for only one day. Therefore the Construction Supervisor should know who is responsible for dewatering and be updated of the status regularly.

The use of cutoff walls can also help control ground water on a construction project site. Water seepage horizontally through the soil can be a major source of water entering a project. A below grade cutoff wall can virtually stop this horizontal flow of water. Interlocking steel sheet piling, is the most common type of cutoff wall. Sheet piling functions best in course grained soils where boulder sizes are generally less then 6 inches, or where there are stratified soil layers and horizontal water flow greatly exceeds vertical. It is important to drive cutoff walls well below the inside excavation elevation.

Top of Page

What Public Domain Documents are available for Further Study?

The US Army Field Manual for Earthmoving Operations is an excellent introduction to sitework equipment and processes. This 202 page handbook is officially called FM 5-434.

Another resource, more useful in the site design area than in construction, but that may be helpful, is the US Dept of Defense Area Planning, Site Planning and Design Manual. It has 79 pages of information that helps one think about how to locate and layout buildings on a site. The official name of this document is UFC 3-210-01A 16 January 2004.

The Dewatering and Groundwater Control Manual produced by the US Dept of Defense provides many details describing water and sitework. The name of this document is UFC 3-220-05 16 January 2004.

Tricks of the Trade & Rules of Thumb for Excavation:

1. Prior to any site work, get several blank site plans and mark them up with color markers showing major site and building staging issues: topsoil piles, fill piles, parking areas, material storage areas, layout locations, etc.
2. Understand the disposal method and location for stumps, trees and brush prior to the start. Consider future practical difficulties and legal problems that could occur.
3. If an offsite dump site is to be used, verify that any required permits are in place.
4. Know demolition scope of work clearly before any work begins (people seem to have no sense of humor when you mistakenly tear their stuff down).
5. When excavation begins do the following:
   a. Grab a handful of topsoil or whatever organic soil there is and squeeze it and get familiar with the texture, color and smell. Keep looking for that soil in places where it shouldn't be.
   b. Grab a handful of soil, squeeze it and do a quick guess of a soil classification per the instructions above. Keep looking if the soil type changes in different areas of the site.
   c. Discuss the soil type with the excavating foreman, learn about the way the soil compacts, passes water, etc.
6. Get Site Contractor to agree to smooth roll and grade to drain at any time rain is expected.

Top of Page